Sound level of compact marine sources

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ABSTRACT

In recent years, the trend has been going towards smaller source arrays in marine acquisition. Apart from reducing any potential environmental impact, the main drivers for this trend are some geophysical and operational advantages of smaller sources. On the one hand, the desire for realizing something closer to a point source for maximizing seismic resolution (e.g., Dhelie et al., 2017), and for another reason the operational efficiency that can be gained by towing multiple sources (Hager et al., 2015). Towing an increased number of (smaller) sources at wider distances from each other also reduces the near offset gap at the outer streamers (Widmaier et al., 2019) which improves shallow imaging without compromising on acquisition efficiency. It has also long been observed that marine seismic image quality is often limited by non-repeatable shot-generated noise, which suggests that marine seismic sources tend to be louder than necessary (Laws et al., 2008).

Reducing the size of marine seismic airgun arrays in practice implies that subarray floats are split up differently to be combined to a larger number of individual source arrays with smaller volume. The trend has been facilitated by improved methods for source signature deconvolution (e.g., Kristiansen et al., 2015) and a more routine application of blended acquisition to ensure a similar inline sampling.

At the same time, traditional airgun arrays are limited in their low frequency output (Parkes & Hegna, 2011). The Gemini source (Brittan et al., 2020) is one of several specialized low-frequency source systems that have been developed in recent years to meet the demand for low-frequency long-offset recordings for full-wavefield velocity inversion. While not exactly small in terms of volume, the Gemini source consists basically of one gun cluster making it more akin to a point source. With these properties, it meets the geophysical needs defined above for smaller sources and offers the flexibility for wider source separations and multiple sources. The lower frequency output of the source ensures more efficient energy transmission to long offsets through the attenuating solid Earth while exhibiting significantly reduced sound output at higher frequencies which is the main environmental concern.

In ultra-high resolution site surveys for wind farms and other infrastructure projects, a compact source with very high frequency output is desired. Typical sources for such applications are sparker- and boomer arrays which can emit energy well into the kHz range. While compact, they cannot be treated as point sources at high frequencies and come with their own unique radiation pattern.

In this paper we will compare the modelled sound output of the mentioned types of marine seismic sources in terms of sound pressure (SPL) and sound exposure (SEL), the typical metric for environmental impact assessment. We will briefly review some of the physical principles governing the sound output of marine source arrays and discuss the importance of bandwidth, as well as array and ghost directivity effects for proper estimation of the sound output into the water column.

We then show how marine seismic source arrays can be adapted to meet respective geophysical needs with minimal sound output.

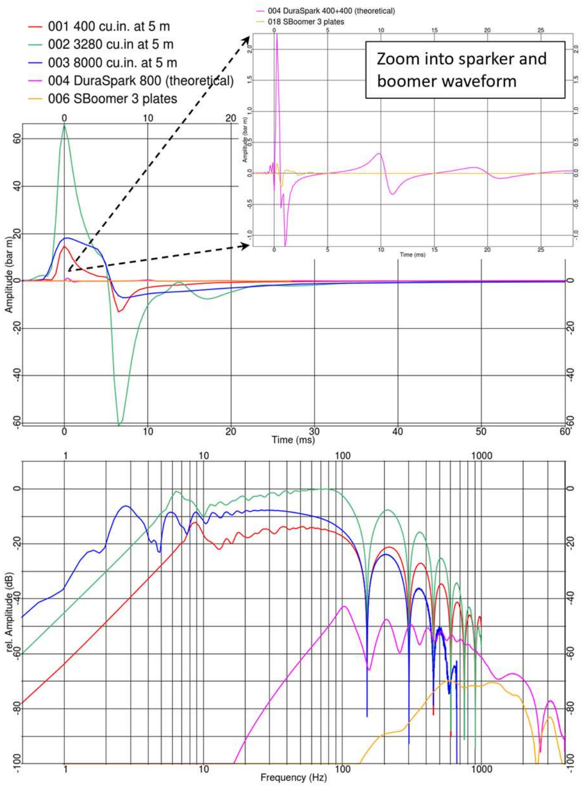

Figure 1: Comparison of vertical farfield signatures and corresponding spectra for different types of compact marine sources. Top: time-domain signatures (with zoom-in for sparker and boomer signature). Bottom: frequency spectrum.

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